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**DEVELOPMENT OF A REMOTELY TRACKABLE DRIFTER**

Final Technical Report

by  
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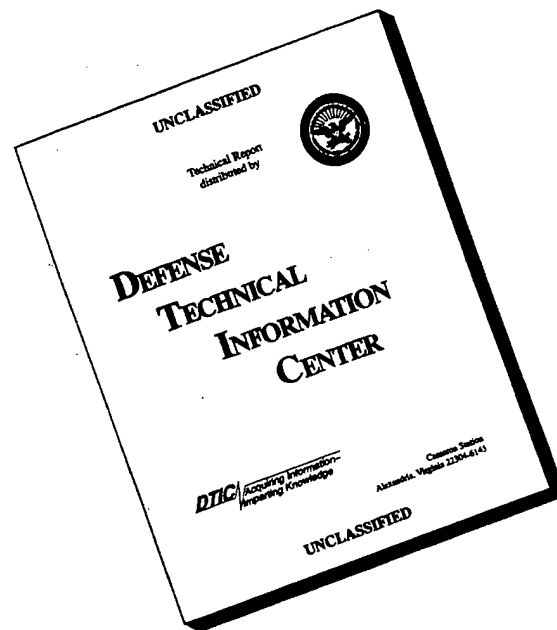
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## FOREWORD

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## **SUMMARY**

This document describes a remotely trackable drifter system which has been developed which will enable up to ten drifter units to be monitored from a vessel or a shore station. The design, configuration and testing of the system is described in detail.

The base station continuously receives data from the drifter units. Individual drifters are equipped with Global Positioning System sensors, radio modems and radios and transmit their position to the monitoring station. The monitoring station consists of a receiving radio, radio modem, personal computer and software.

Each component of the entire system has been tested and proved under field conditions. If differential correction is not undertaken, positional accuracy of about 100m can be expected. If differential correction of the data is completed, positional accuracy of better than 10m can be expected.

The design has been proved at the prototype stage, expanded, composite systems consisting of larger numbers of drifter units (up to 10) can now be constructed and put into use in a range of estuarine and coastal applications.

## **KEYWORDS**

Global Positioning System, Drifter, Position Monitoring Systems

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## 1. INTRODUCTION

Within this report, a drifter is defined to be a solid instrument designed to trace the motion of a parcel of water within coastal or estuarine flow systems. For most field studies, they consist of some sort of surface marker (which enables their position to be monitored) tethered to a drag unit (a drogue) which is weighted to remain a fixed depth below the surface. However, far simpler, disposable drifters in the form of oranges or punch cards have also been used for field studies.

The tracking of drifters is a key component within the range of techniques available to coastal engineers and oceanographers in the investigation of flows in estuaries and coastal seas. Drifter position is currently recorded by repeated visits by the monitoring vessel which forces a number of constraints on their application. Because the vessel must traverse between drifters to update their position, a significant time is taken and this can lead to degradation and ambiguities in the captured data. Also, as sea conditions develop or night falls, the drifters become less visible which, in turn, increases the probability of their being lost and the time between positional updates increases even further. For investigations in coastal waters, drifter exercises can only be undertaken in relatively mild wave conditions and daylight hours. It is generally impractical for a single vessel to monitor more than six drifters in a single exercise under calm conditions, or more than three under mild (2m height) wave conditions.

However, if the position of a large number of drifters could be continuously and remotely monitored, the information obtained from field studies would be greatly enhanced and the applicability of the technique would be broadened.

This report contains a review of available means of remotely tracking drifters and documents the proving of a system based on the global positioning system (GPS).

## 2. PROJECT DEVELOPMENT

### 2.1 Initial Review

During the conceptual design of the remotely trackable drifter system, a wide range of positioning techniques were considered. A brief review of these is presented herein.

*Electromagnetic Distance Measurement* equipment which has been used for boat positioning is not amenable to drifter application – the emitters are not very robust and are quite expensive.

*Radio beacons* have been used (Davis, 1985) but preliminary investigations showed that such a system would be too expensive to justify the development.

*Acoustic beacons* were considered (transmitting underwater) but the sensors are relatively expensive and the commissioning of a reliable design in waters of complex bathymetry and stratification would be difficult.

The *ARGOS* satellite-based system is available for monitoring drifter position. Whilst the system provides monitoring in regions that are otherwise inaccessible, the positional updates provided by this system are at relatively low frequency. The *ARGOS* system has been used for tracking drifters over very long distances in the deep ocean where the frequency of positional updates is adequate (Sombardier and Nijler, 1994).

*RADAR reflectors* were investigated in some detail but there appears to be no means of enabling individual drifters to be distinguished at moderate cost.

*GPS* sensors have become widely available and a rapid reduction in sensor cost has also been observed in recent years. By combining such sensors with readily available radio telemetry equipment, it was judged that drifters fitted with such sensors would provide drifters which were robust, had a distinct signature and could be constructed at moderate cost.

### 2.2 The GPS System

The GPS system has been progressively established by the United States Department of Defence to provide a world-wide navigation system. It reached its now fully operational form in 1993. It consists of 24 satellites orbiting 20000km above the earth's surface, these being controlled by a master station in Colorado and monitored in conjunction with four other sites around the world.

Two positioning codes are transmitted by the satellite system: precise (P) code which is encrypted (and only available to authorised military users) and civilian access (C/A) code which is available for general navigational use. GPS sensors receive broadcast data from the satellites and (provided that four or more satellites are available) derive from them their three-dimensional position relative to an assumed datum. The RMS error associated with computed horizontal position using C/A code is roughly 25 metres. However, what is termed selective availability (SA) was commissioned by the U.S. Military to reduce this accuracy and thereby protect allied forces during hostilities. With SA applied (as it normally is), the C/A accuracy is downgraded to approximately 100m.

Manufacturers have been diligent in exploring means of increasing the accuracy of position fixes on roving vehicles via GPS sensors. Only one technique is relevant to our discussion of mobile nautical position fixing. By maintaining a fixed base station at a known location and monitoring certain errors inherent in the GPS system (including SA), corrections can be applied to the position of the roving stations thereby reducing the error in the estimated position to about 10 metres.

Some GPS manufacturers may argue at these stated accuracies and occasionally the GPS system is more accurate. However, higher accuracies are not possible for roving systems where the GPS antenna may be obscured intermittently.

### 2.3 Schematic Design

GPS sensors are supplied by their manufacturers in a range of configurations. Most often these are seen as portable units usually with a detachable aerial and some sort of keyboard interface. However, the core units of the sensors are readily available and consist of a printed circuit board with a dedicated microprocessor and connectors for the aerial, power and serial communications.

To enable units fitted with these sensors to be remotely trackable (that is, to relay position to a monitoring station), each unit had to be fitted with a radio modem/radio pair. CPU-50 radio modems coupled to Maxon radios were selected. These have previously provided a reliable communications link in the telemetry of instrument data in projects by groups associated with Water Research Laboratory (Australian Water and Coastal Studies Pty Ltd and Manly Hydraulics Laboratory).

Two attractive features of these radio modems is their permanent connection and multi-connect capabilities (GFS, 1985). By configuring a radio modem for permanent connection to another, the modem will continuously try to re-establish the communications link if it is broken. Given the real probability of the aerial being obscured by wave action or landform, this is a highly desirable feature. The multi-connect feature permits a number of modem units to simultaneously connect to a single destination unit. The incoming streams of information from different sources are identified at the destination unit by prefix strings in its output stream.

The uniqueness of the individual components already discussed has led to a "bottom up" style of design. Other necessary components such as the instrument housing, buoy, power supplies and computers fitted with appropriate software to identify and store the received drifter positions complete the overall design. The complete schematic design is as shown in Figure 1.

### 2.4 Development Programme, Testing and Results

At the design stage, a programme was devised to ensure the development and reliable operation of the system in the field. This was to include the following:

1. Selection of appropriate GPS units
2. Development and sensitivity testing in the laboratory
3. Testing on an inland reservoir
4. Construction of two further drifter units with appropriate interfacing
5. Testing of the entire system within an estuary
6. Testing of the entire system offshore

At each stage of development, system integrity was to be reviewed and modifications undertaken, if necessary.

The offerings of a number of GPS manufacturers were reviewed and based on their specifications, units from Magellan Systems Corporation were initially selected.

A roving test unit and the base station were manufactured and tested in the laboratory. Their operation proved to be satisfactory.

It was decided that testing on an inland reservoir was not very demanding given that the velocities would be low and that there was no possibility in a break in the radio transmission. Instead, the roving test unit was mounted on the rear of a vehicle and driven some 10 km over undulating terrain with relatively high density development. Data transmission was broken many times and the buffer of the remote unit overflowed but in each case the telemetry system recovered and reliable data transmission was resumed with reconnection. The acquired data is presented in Figure 2.



Two complete drifter units were then constructed, including the requisite data acquisition systems, buoyancy, waterproof housings and radio masts. Drawings of their physical arrangement and electrical details are contained in Appendix D.

It was at this point in the project that a serious problem with the differential correction of the data supplied by the Magellan units was revealed. Whilst the Magellan documentation had stated that the ephemeris data required for differential correction could be supplied, detailed testing revealed that this was not the case. The problem was referred to the manufacturer who subsequently revealed that the necessary data could not be obtained from these units. It then became apparent that a significant delay was going to be incurred whilst further review of available GPS units was undertaken.

It was decided to proceed with testing of the system offshore with the Magellan units as the lack of differential correction was less likely to be significant and the project could proceed to the staged proving of reliability of the multi-connect transmission of the radio modem system. The system was tested in the coastal waters offshore of Sydney and the transmission system was confirmed as being reliable. The drifter paths (without differential correction) as recorded during this exercise are shown in Figure 3. The offshore current, wind and ocean temperature conditions recorded at the Ocean Reference Station during the exercise are shown in Figures 4 and 5. It is apparent that there are significant windage effects on the drifter unit as tested in this case with only a 0.5 m diameter drag net set 1 metre below the drifter..

The review and selection of another suitable GPS unit took some time. A number of manufacturers were only able to satisfy the requirements, provided that an on-board computer was fitted to the drifter. Such an arrangement was rejected due to the cost associated with the purchase and configuration of such computer boards and the additional power storage which would be required by the drifter at sea.

The only offering at moderate cost which appeared to be suitable was the SVeeSix of Trimble Navigation Limited. A test unit was purchased fitted with the manufacturer recommended TSIP protocol.

The unit was tested under laboratory conditions where it became apparent that the TSIP protocol was exceedingly verbose. Large quantities of useless data were transmitted by the unit under conditions when contact with the satellites was intermittent. This would significantly increase the transmission load for the radio modem system and perhaps lead to system breakdown. This problem was referred to the manufacturer who confirmed the problem and subsequently recommended the fitting of an on-board computer.

Within the SVeeSix documentation, a second protocol (TAIP) was described which appeared well-suited for the drifter application. Consultation with other users revealed that data supplied by this protocol was filtered by the unit and would be unsuitable for differential correction. Enquiries were then made with the manufacturer as to whether the unit could be reconfigured to transmit TAIP with the filtering removed. The presence of the filtering was confirmed but some two months of prompting were required for a reconfiguration program to be supplied. Further laboratory testing proved the suitability of this modified protocol for both robust transmission and differential correction.

The SVeeSix unit was fitted to one of the drifter units and deployed in a Sydney estuary. The unit performed well. The post-processed differentially corrected data are shown in Figure 6. The predicted tide for the day of testing is presented in Figure 7.

The testing programme was concluded with all aspects of the remotely trackable drifter system having been successfully tested and proven. A detailed description of the proven components and their configuration is contained in the following section.

### 3. SYSTEM COMPONENTS AND CONFIGURATION

#### 3.1 General System Description

Figure 1 shows the conceptual design envisaged early in the project. The final overall system configuration with the details of components, their connections and data communication rates are shown in Figure 8. The configuration details of each component are described in the following sections with the hardware description sheets being presented in the appropriate appendix.

#### 3.2 GPS Unit

The GPS unit proven and selected for use is the Trimble Navigation Limited's SVeeSix, a six channel GPS sensor (Trimble, 1992). Manufacturers specifications are contained in Appendix A. The unit is configured with a specific version of the TAIP protocol which has no digital filtering of estimated position. Reconfiguration of SVeeSix units can be undertaken by Trimble or by Water Research Laboratory. The TAIP messages requested from the SVeeSix are the long navigation (LN) and time/date (TM) messages. The RS-232 communication parameters of the SVeeSix using TAIP are 4800 baud, eight data bits, one stop bit and no parity bit. The recommended update rates for these two messages are 3 per minute and 1 per hour respectively. For each sensor, this is approximately equal to 16kbytes per hour. The units are reconfigured to deliver the required messages by the appropriate TAIP messages and a terminal emulation program.

Battery backup for the GPS unit RAM has been fitted so that programmed parameters will be retained at system shutdown and during exchange of the main battery system.

#### 3.3 Radio Link

The communications link between the drifter and the shore is provided by a radio link controlled by the CPU-50 radio modems manufactured by GFS Electronics coupled to radios supplied by Maxon. A general description of the units used and their specifications are contained in Appendices B and C. These units were selected because they have:

- previously been used by Manly Hydraulics Laboratory and Australian Water and Coastal Studies Pty. Ltd. on a number of projects and had operated reliably;
- a battery-backed facility which enables them to retain their prior configuration; and,
- their relatively low cost.

The radio link was operated at 120 bytes per second on the VHF FM frequency of 151.11 MHz. Such a communication rates should be adequate for up to ten drifter units. Although not tested, the documented maximum capacity of a CPU-50 network is 10 units.

Distinct CPU-50 configurations were required for the drifter units and the base station.

The drifter units were configured to remain permanently connected to the shore station. Their RS-232 communication parameters were set to match the SVeeSixs. At power up, these units connect to the shore station and transparently transmit all binary data received on their serial ports from the GPS units. Such a configuration enables the units to be powered up on the water and immediately start communicating their position to the shore station with no programming in the field. The parameter settings used are as shown in Table 1 below.

**Table 1**  
**Radio Modem Settings For Remote Units**

Parameter	Setting
CONPERM	ON
CONNECT	1
CONMODE	TRANS
8BITCONV	ON
AWLEN	8
PASSALL	ON

The shore station was configured for no permanent connection, with first available address. Its RS-232 communication parameters were set for maximum throughput at 9600 baud, eight data bits, one stop bit and no parity bit. At power up, this unit awaits remote connection and transparently transmits all binary data received from the GPS units. Additional configuration is required for the shore station to identify the different channels of communication. Communication must be permitted on any free logical channel, four characters are transmitted to identify a change in stream, two "I" characters followed by the channel identification character and a colon ":". The radio modem settings are summarised in Table 2.

**Table 2**  
**Radio Modem Settings For Base Unit**

Parameter	Setting
CONPERM	OFF
MYADDR	1
CONMODE	TRANS
8BITCONV	ON
AWLEN	8
PASSALL	ON
CHSWITCH	1
CHDOUBLE	ON
USERS	0

### 3.4 Buoy and Instrument Housing Construction

Drifter buoyancy hull used during the testing programme were constructed of polystyrene foam coated in fibreglass. Their overall diameter was 1.2m diameter with an internal well diameter of 0.45m.

The instrument housings were constructed from PVC and were designed to accommodate the electronic components and batteries. The overall dimensions of the housings were 450×200×100mm and were designed to accommodate the necessary components and fit within the internal well of the hull. Waterproof glands were used to provide cable access to the aerials. One metre aerial masts were fitted to the instrument housings.

Drawings of the final arrangement are shown in Appendix D. Photos of the housing and hull are shown in Figure 9.

### **3.5 Shore Station Computer**

The computer used to receive the incoming data was a PC laptop operating under MS-DOS. The minimum PC requirements are a 80386 processor with 2Mb RAM and a floppy or hard disk are required for the logging of 10 drifters. The COM1 port of the PC was used to configure the drifter units before deployment and to parse the incoming data during field exercises. The program *rtparse.c* has been written to identify and split the incoming data streams, display the current drifter location on the screen, and store the received data from each drifter in its own file.

### **3.6 Power Consumption**

A single drifter unit was able to transmit its position for some 18 hours using a single 12V, 7Amp.hr battery.

#### **4. DIFFERENTIAL CORRECTION**

Post-processed differential correction of the gathered drifter data was provided by the School of Geomatic Engineering, University of New South Wales. Post processing differential correction software was not commissioned as part of the research contracts – it would, however, be made available by negotiation.

The software imports data in RINEX format from any all-in-view base station GPS receiver to correct the data received from the drifters.

Real time differential correction would be possible depending on the update rate from the drifter units and the processing capability of the base station computer. However, substantial program development would be necessary before such a system could be commissioned and there is generally little need for such accurate position fixing in real time.

Data collection exercises can effectively proceed using the uncorrected, raw data. Post-processing differential correction can then be carried out after completion of the exercise.

## 5. CONCLUSIONS AND RECOMMENDATIONS

A remotely trackable drifter system has been developed which will enable up to ten drifter units to be monitored from a vessel or a shore station. Individual drifters are equipped with GPS units, radio modems and radios and transmit their position to the monitoring station. The monitoring station consists of a receiving radio, radio modem, personal computer and software. The developed software identifies the transmitted positional fixes from the drifter units, displays their current positions and stores the collected data for differential correction at some later time.

Each component of the entire system has been tested and proved under field conditions. If differential correction is not undertaken, positional accuracy of about 100m can be expected. If differential correction of the data is completed, positional accuracy of better than 10m can be expected.

A buoyancy hull design has been prepared, suitable for longer deployments in coastal waters. However, modification to this design to reduce windage in estuarine waters is recommended.

The design has been proved at the prototype stage, therefore it is recommended that expanded, composite systems consisting of larger numbers of drifter units (up to 10) be constructed and put into use in a range of estuarine and coastal applications.

## 6. REFERENCES

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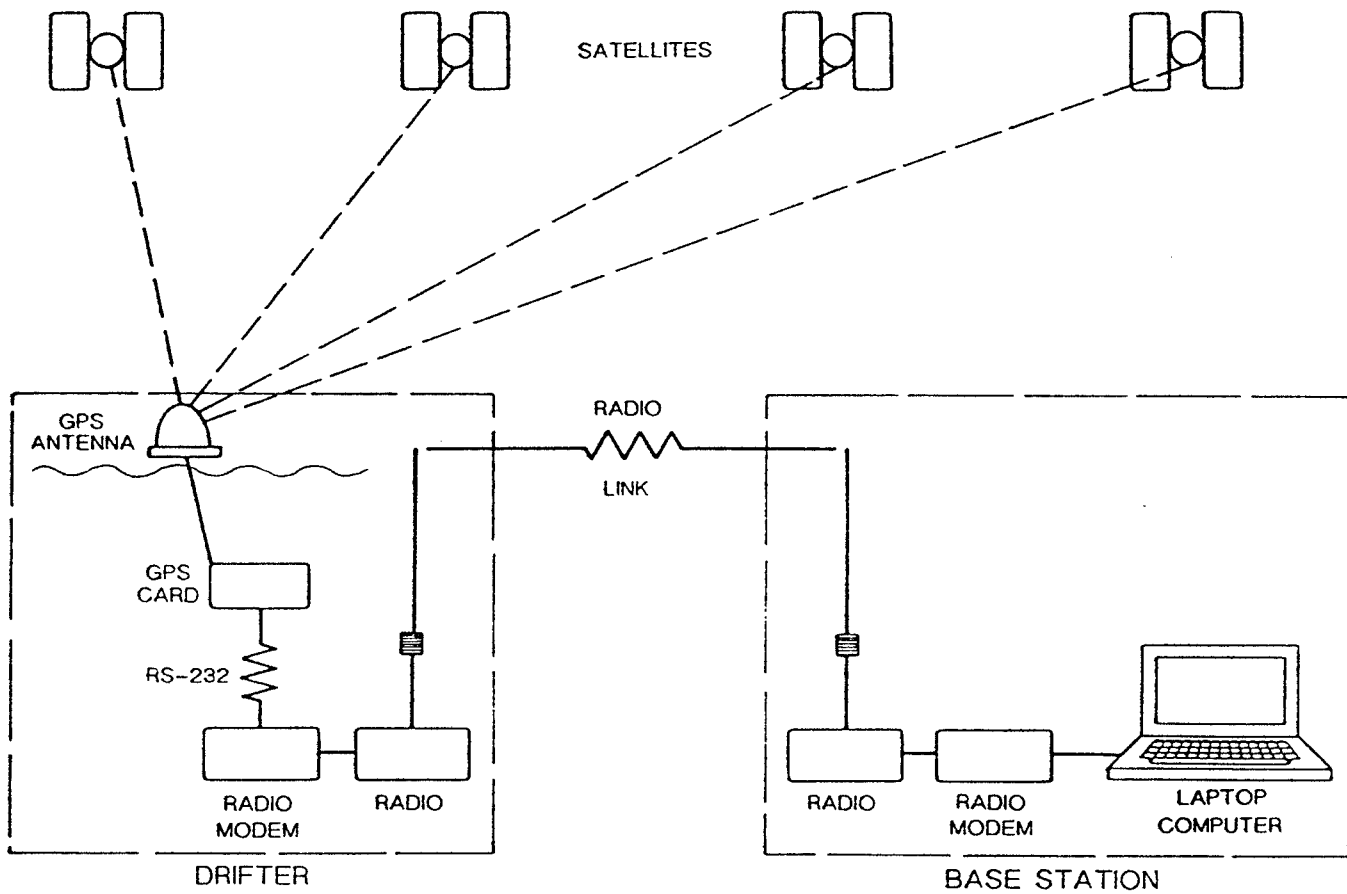
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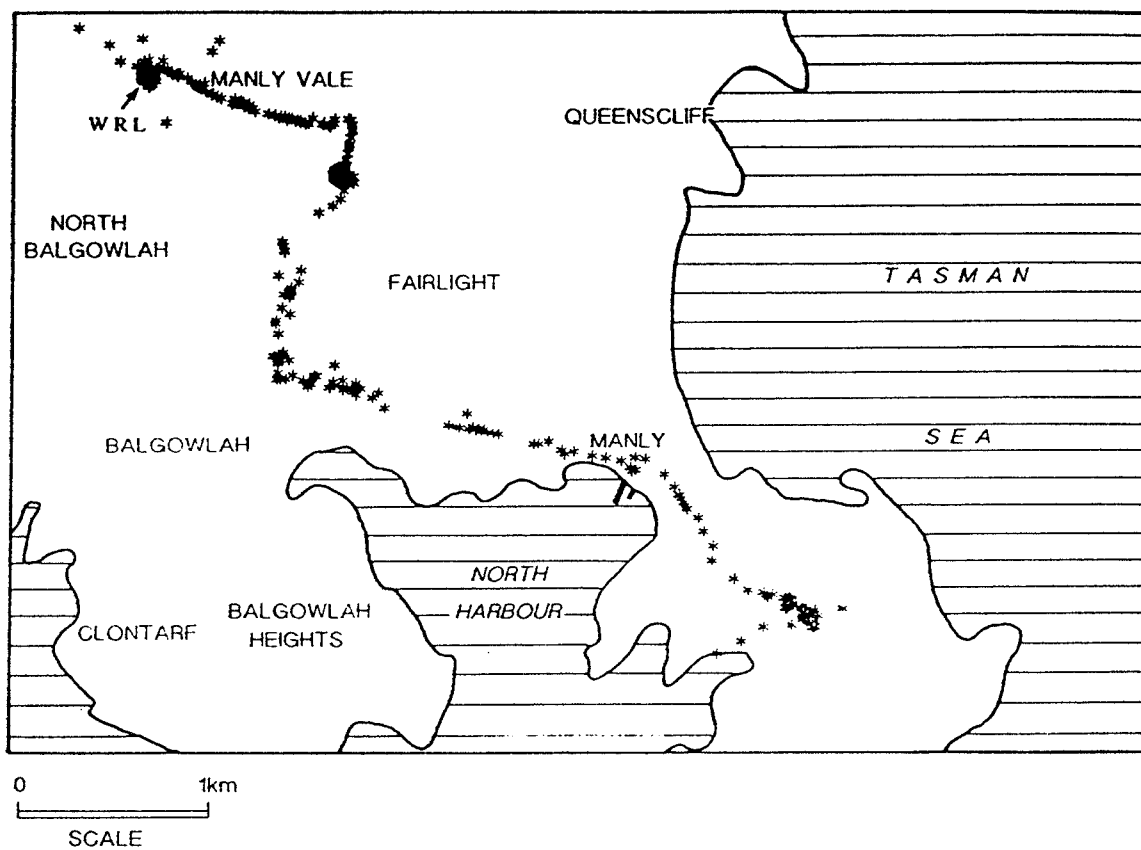
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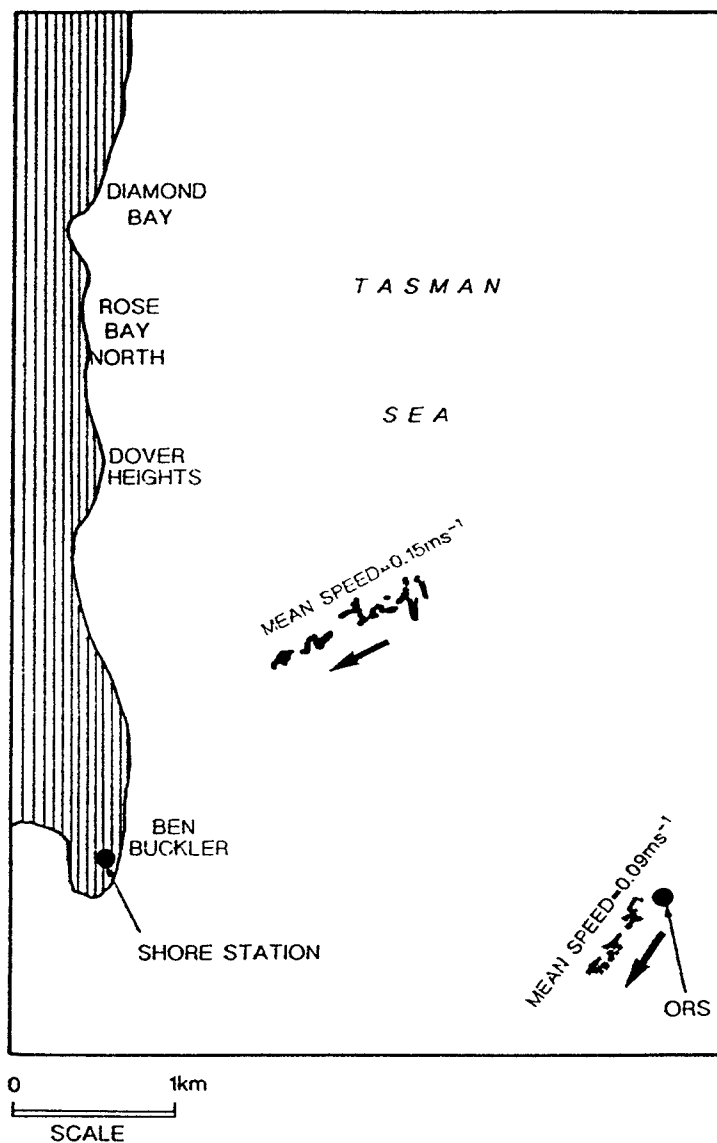
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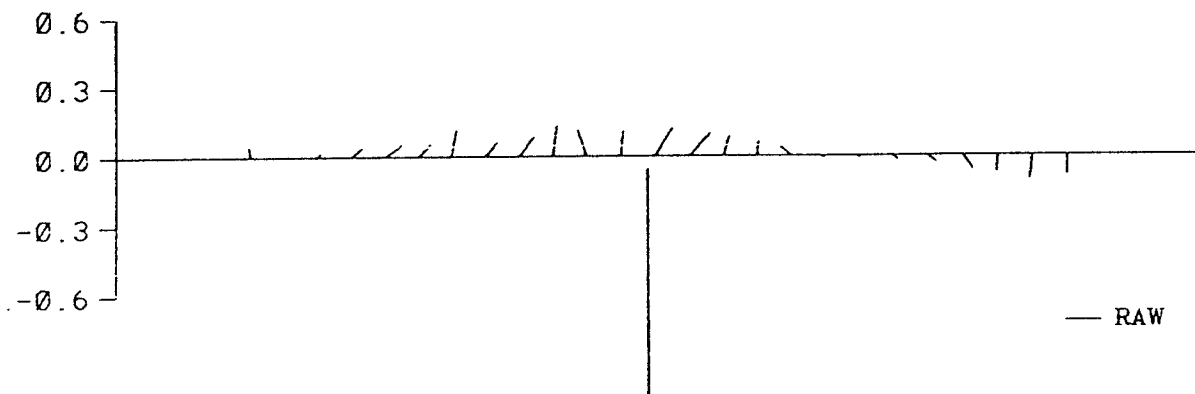




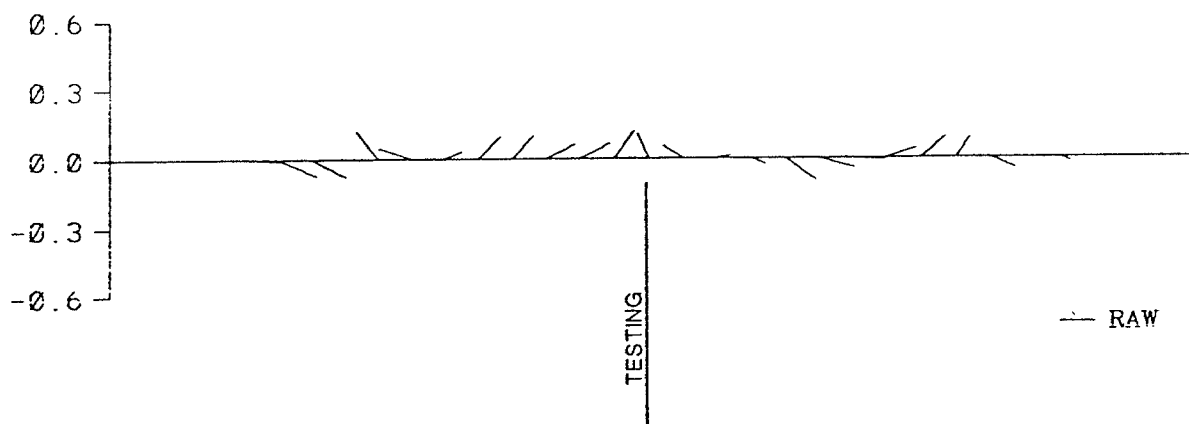


ORS CURRENT DATA. 08-FEB-95 0000 TO 09-FEB-95 0000

DEPTH : 17 m

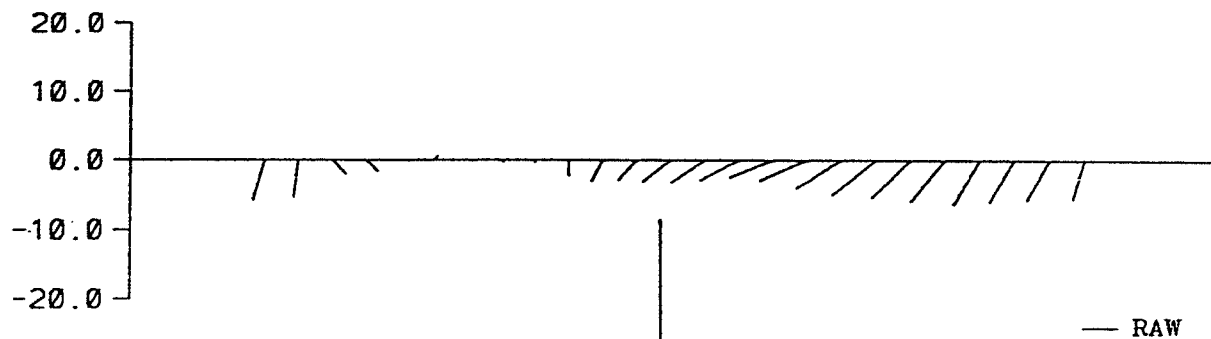


DEPTH : 52 m

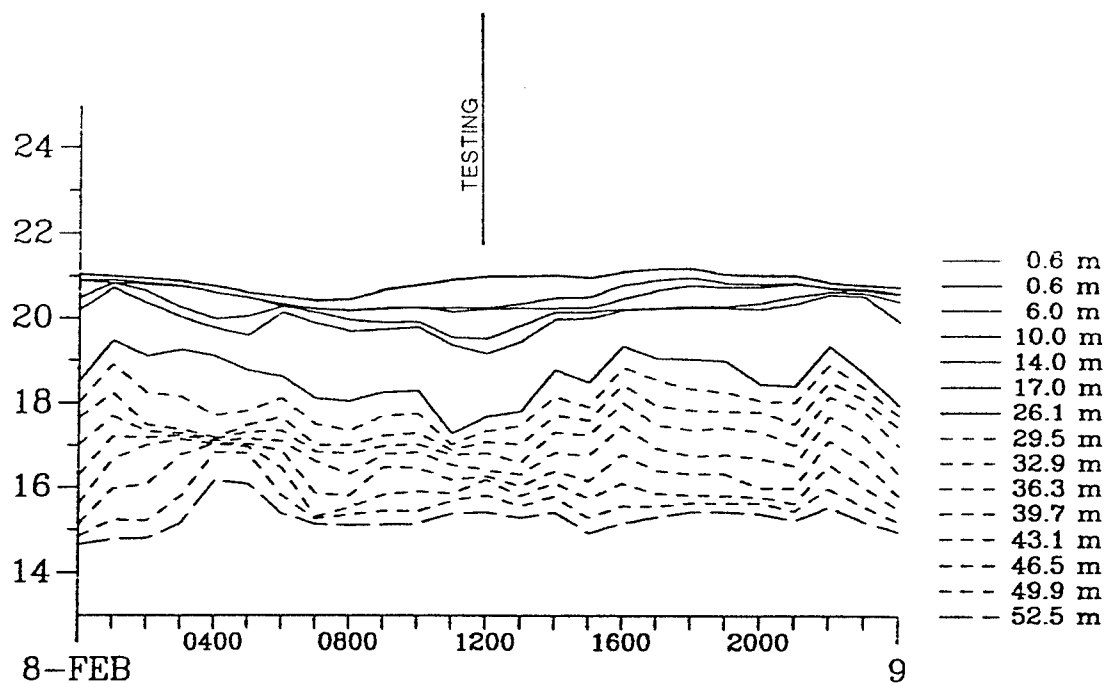


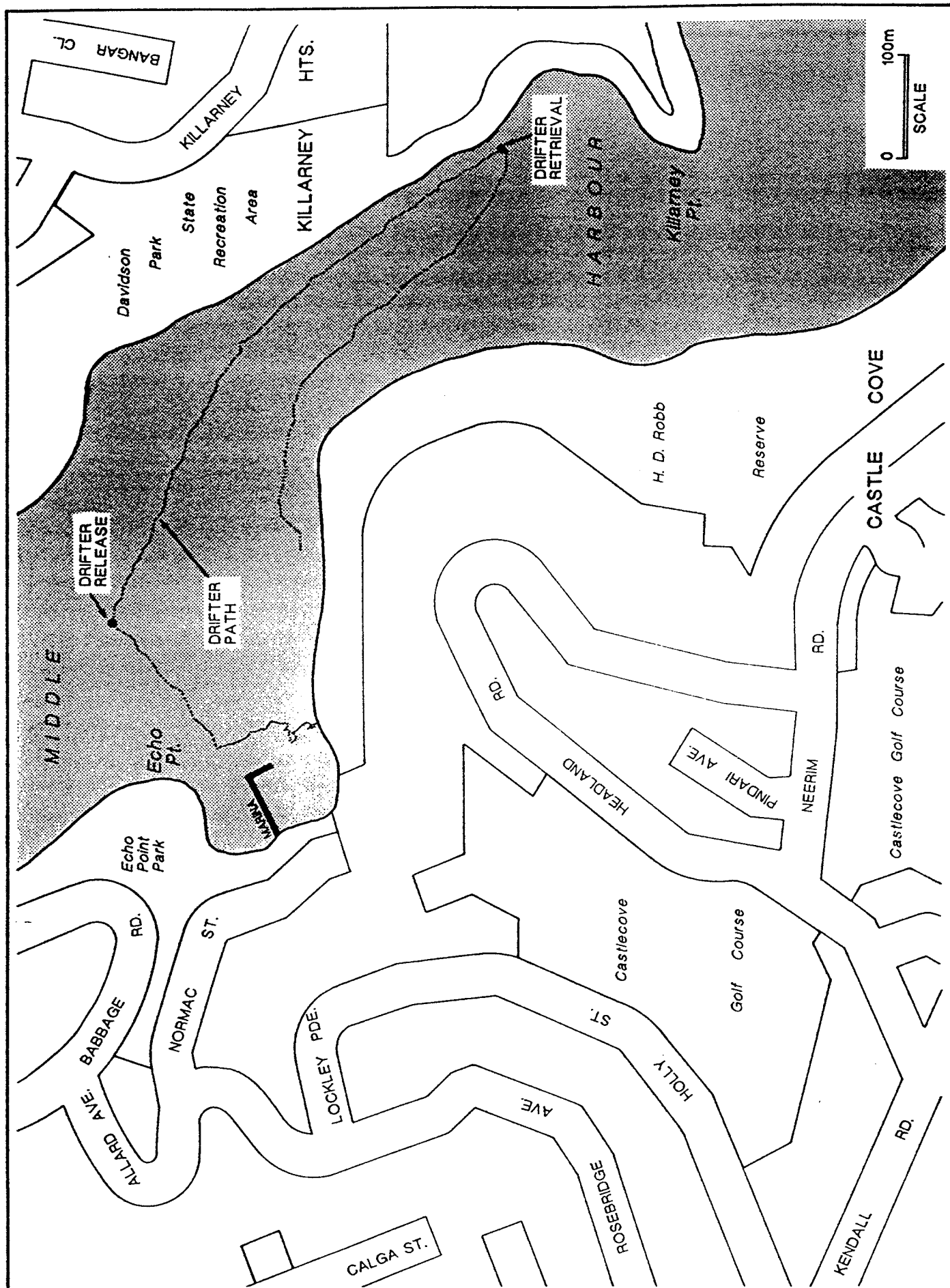
8-FEB 0400 0800 1200 1600 2000 9

ORS WIND DATA. 08-FEB-95 0000 TO 09-FEB-95 0000



ORS THERMISTOR DATA. 08-FEB-95 0000 TO 09-FEB-95 0000





# Tuesday 18

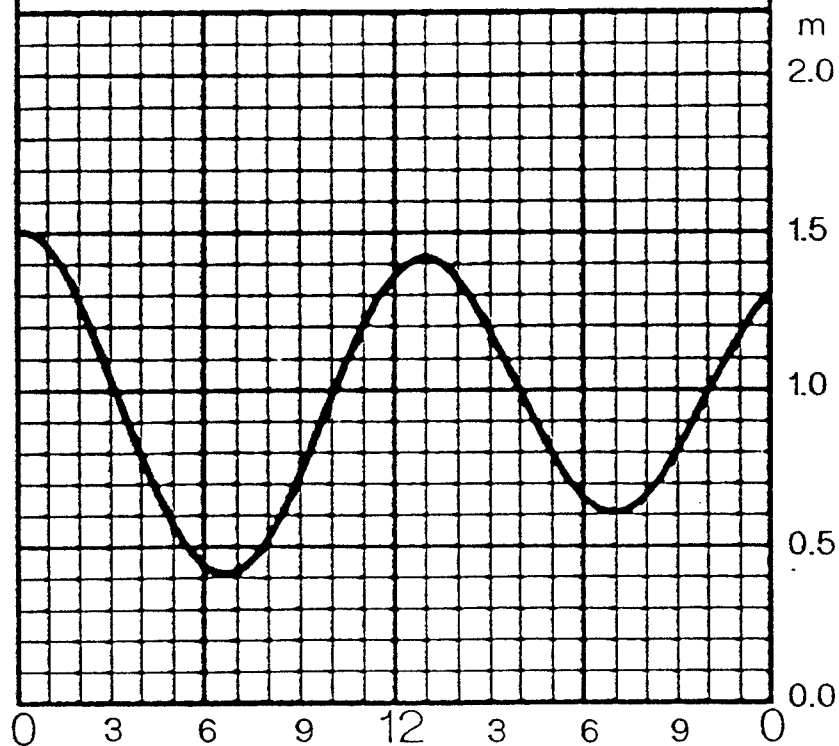
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Sunset	5.06 pm
Moonrise	11.25 pm
Moonset	10.26 am

Note:

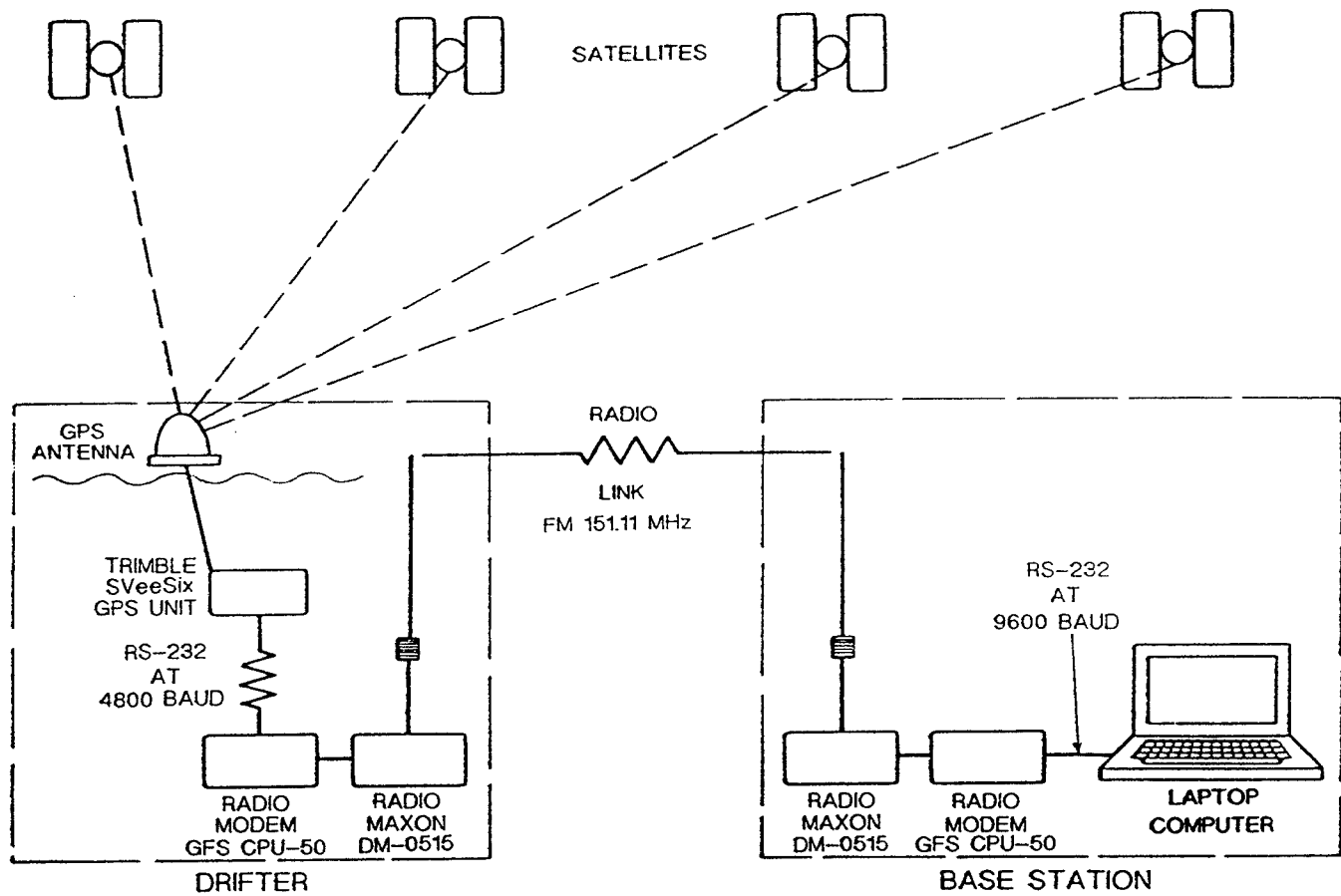
All times to Australian  
Eastern Standard Time.  
All heights in metres.

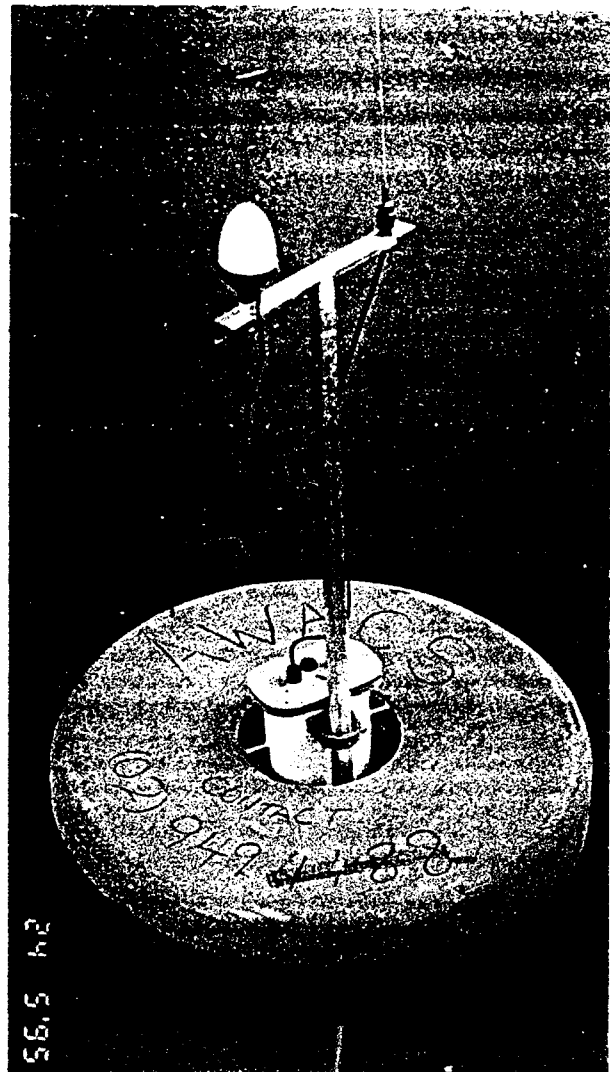
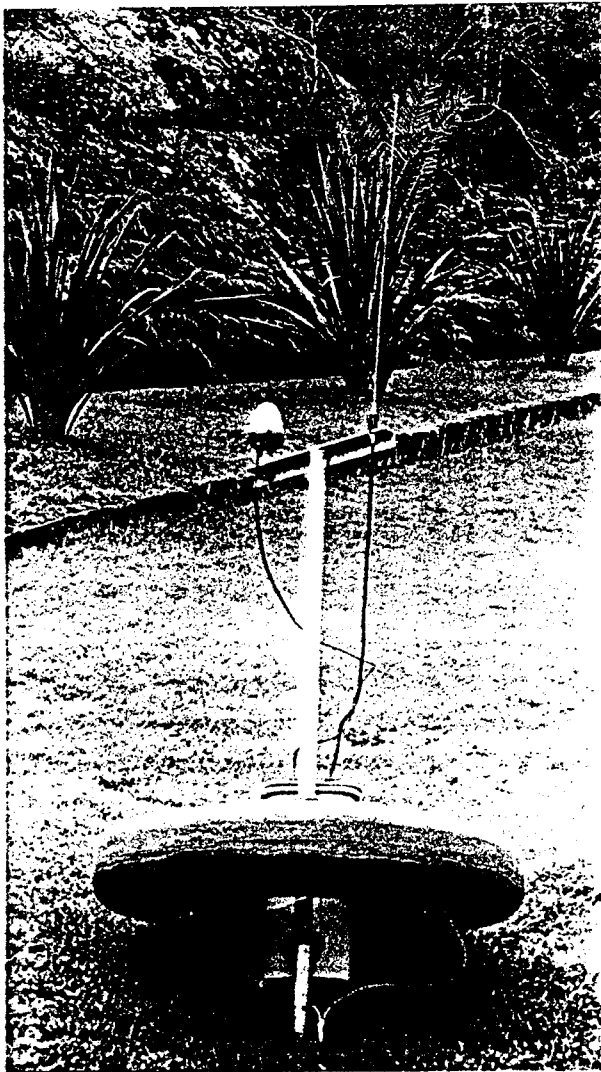
High	12.10 am	1.5 m
	12.57 pm	1.4 m

Low	6.41 am	0.4 m
	6.59 pm	0.6 m



Source: PWD, 1994







## **APPENDICES**

**Appendix A: Trimble SVeeSix Description and Specifications**

**Appendix B: Hardware Description Sheets For Radio Modem**

**Appendix C: Hardware Description Sheets For Radio and Aerial**

**Appendix D: Technical Drawings of Drifter Unit and Shore Station Housing**

## **APPENDIX A**

### **Trimble SVeeSix Description and Specifications**

## 2.0 SYSTEM DEFINITION

### 2.1 General Functional Description

The SVeeSix series provides an OEM or system integrator with a low cost, high performance GPS SPS (Standard Positioning Service) receiver boardset (SVeeSix) or module (SVeeSix Plus) which uses the C/A code on the L1 frequency carrier. It is designed for use in large volumes by OEMs and system integrators who require a high quality GPS unit within their system or product design. The series is tailored to provide the optimum specifications for each application. Variants of the series are available to provide rapid acquisition on start-up, fast updating, and a selection of interfacing protocols.

Flexibility of mechanical installation is recognized as an important consideration in the design of the series. The exceptionally small size, power requirements, use of standard connectors, and low heat dissipation, allow easy integration with other system components. Standard form factors are described in this document; using the CDP approach, other form factors can be made available on request. If a stand alone design solution is preferred, the SVeeSix Plus has an optional sheet metal enclosure fitted for; data transfer (either one or two DB-9 connectors depending on configuration), power (Conxall Micro-Connector), and antenna signal input (SMB).

The SVeeSix series provides position accuracy's specified at 25 meters spherical error probability (SEP). The DOD reserves the right to implement selective availability (SA) of accuracy. Under these conditions, position accuracy will be degraded to 100 meters (2 dRMS) and velocity accuracy will also be reduced.

The system receives GPS satellite signals using a low profile microstrip, patch type antenna, amplifies the signals, and sends them to the receiver board. The board uses six channels for tracking up to 8 satellites, automatically selecting the optimum satellite combination in parallel to ensure the most accurate position solution possible.

The SVeeSix series provides interfaces for data input and output with other equipment provided by the customer using either:

Electrical -	RS232
	RS422
	TTL (Flexible PCB Connector)
Data Protocols -	Trimble Standard Interface Protocol (TSIP)
	NMEA 0183 (GGA and VTG)
	Trimble ASCII Interface Protocol (TAIP)

The primary output of the SVeeSix is time-tagged position and velocity at intervals of approximately one second. Other available information includes satellite status, dilution of precision factors (PDOP, HDOP, VDOP, etc.), and diagnostics of sensor operational status, depending on the protocol chosen; the default protocol is TSIP. Output information is communicated digitally via single or dual EIA RS-422 or RS-232 data ports. The optional second data port is dedicated to DGPS corrections using the RTCM 104 protocol.

The SVeeSix automatically selects the satellites which it tracks, but the operator optionally may mask (exclude from selection) satellites which provide less than a specified received signal level, or are either lower than a specified elevation above the horizon, or in poor health. The operator may specify; minimum acceptable dilution's of precision and position solutions in either 2 or 3 dimensions, plus several criteria to optimize performance under different operating conditions.

The SVeeSix is completely self-initializing from a cold start. On board memory stores information to speed the initialization, but the operator optionally may input new information (e.g., approximate location following a long move after the SVeeSix last was used) to speed the initialization further. The on board memory can be supported when the GPS board is not operating. this can be accomplished by supplying an external feed from a battery or other source drawing less than 100 micro amps.

## 2.2 Abbreviated Specifications

Channels:	6 channels, tracking up to 8 satellites.
Antenna:	Low profile microstrip patch type.
Antenna Cable Loss:	10dB max at 1575 MHz.
Position Accuracy:	25 meters spherical error probability (SEP), 100 meters (2 dRMS) if Selective Availability (SA) is enabled.
Differential Accuracy:	Less than 10 meters.
Velocity Accuracy:	Steady rate conditions, without SA: 0.02 m/sec .
Acquisition Rate:	
	Momentary signal interruption: Less than 5 seconds.
	Momentary power interruption: Less than 90 seconds with battery backup. Less than 30 seconds with Real Time option.
Data I/O:	
TSIP:	Trimble Standard Interface Protocol. RS-422 and RS-232. Maximum control over all GPS board functions. Sample C source code for interface routines available on request.
TAIP:	Trimble ASCII Interface Protocol. Bi-directional, including DGPS.
NMEA:	Marine standard interface — Uni-direction (output only) GGA, VTG (available upon request ALM, GSA, GSV, RMC, ZDA).
Outputs:	Position, velocity, time, PDOP, updates less than once per second.
Inputs:	Mode settings, I/O configurations, velocity aiding.  RTCM 104 Differential GPS corrections, including TSIP, TAIP, and NMEA.
Mechanical:	Single DB-9 female (standard).  Dual DB-9 female (optional).  Optional Elco 25 way flexible PC Connector for both power and TTL I/O.

**1 Pulse-Per-Second Output:**

**Timing:** Falling edge of pulse synchronized to UTC within 1 microsecond.

**Width:** 1 microsecond. Falling edge of pulse is 20 nanoseconds or less, depending on distributed capacitance in cable.

**Output:** Open collector

**Dynamic Capability:**

**Velocity:** Max 400 m/sec

**Acceleration:** 4 g (39.2 m/sec<sup>2</sup>)

**Jerk:** 20 m/sec<sup>3</sup>

**Note:** Mechanical configurations must also be checked, since mechanical stress limitations are more likely to be the performance limiting parameter in extreme dynamic applications.

**Temperature:**

**Operating:** -10°C to +60°C (standard board)

-40°C to +85°C (optional board)

-40°C to +85°C (antenna)

**Non-operating:** -55°C to +100°C

**Vibration:** 0.008g<sup>2</sup>/Hz 5Hz - 20Hz

0.05g<sup>2</sup>/Hz 20Hz - 100Hz

-3db/octave 100 - 900Hz

**Note:** Specifications Comply With SAEJ1211 Requirements

**Altitude:** - 400 to +18,000 meters MSL

**Humidity:** 5 - 95% R.H. condensing @ 60° C

**Prime Power:** 9 - 32 VDC input (standard)

5 VDC input (optional)

1.85 Watts nominal (w/o FOG antenna) - 2.00 Watts nominal with FOG antenna

Add 200 mWatts for RS-422 electrical interface

Reverse polarity protection

Mechanical connection - 3-pin Connall

Battery back-up - 3.5 - 32 VDC (current draw - less than 100 micro amps)

**Dimensions:**

**Board:** 103 mm x 92 mm x 20 mm (4.06" x 3.6" x 0.8") \*

**Module:** 127 mm x 102 mm x 28 mm (4.97" x 4.03" x 1.1") (without mounting flange)

**Module Flange:** 173 mm x 102 mm x 2 mm (6.81" x 4.03" x 0.062")

**Antenna:** 60 mm (2.36") dia. Overall external dimensions dependent on form and mechanical mounting of radome assembly.

**Weight:**

**Board:** 80 g (0.18 lbs.) (with twin DB-9 connectors)

**Module:** 260 g (0.57 lbs.) (including mounting flange)

**Antenna:** 60 g (0.13 lbs.)

**Connectors:**

**Power:** Micro Conxall connector, 3 pin male socket plug (SVeeSix Plus)

3 pin type (0.1 inch centers) right angle header (SVeeSix)

**Data I/O:** Single DB-9 connector (standard)

Dual DB-9 connectors (optional)

**Antenna:** Coaxial SMB

**Availability:** OEM and System integrators evaluation kit (P/N 21589-00)

Bulk Supply - Boards  
- Modules  
- Radomes

Special requirements to order

**\*Note:** Board layout and design is configurable to meet specific customer requirements and applications. Options and formats prescribed will determine final board size and layout. Board sizes can vary from a minimum of 2" x 2 1/2" to a maximum of 8" x 11".

## **APPENDIX B**

### **Hardware Description Sheets for Radio Modem**

Transmission of an average size packet takes around a half second. A large data file would be sent in a series of "bursts" or high speed packets, machine gun style.

The packet radio protocol and the CPU-50's unique Digital Signal Processing (DSP) front end gives a very high immunity to radio frequency noise or interference resulting in an error free high data throughput.

#### Error Checking

When a data packet has been assembled, it is automatically transmitted by the radio system. Although the packet will be heard by all CPU-50's within range on the same channel it will be ignored by all except the one to which it was specifically addressed. On receipt, the addressed station will immediately check the validation bits which are held within the packet's overhead. If the packet is correct, a positive acknowledgment (ACK) is sent to the originating unit confirming receipt. If the data was in error no ACK will be transmitted, causing the sender to retransmit the data. The number of data retries is defined by the user (1 to 15 or infinite).

The validation process is essential to the correct operation of a packet system. There can be a variety of methods used, ranging from simple parity sums to sophisticated Cyclic Redundancy Checks (CRC). Parity checking is easy to implement but suffers from an inability to detect two bit inversions. The CRC is much more complicated but offers corresponding improvements in performance. The CPU-50 uses a sophisticated 16 bit CRC method thus ensuring virtually any possible error condition.

#### Spectrum Utilization

The CPU-50 smart radio modem uses a "listen before transmit" scheme or Carrier Sense Multiple Access (CSMA). This means only one unit transmitting at a time. In order to understand spectrum utilization, something must be known about the average data traffic generated by a CPU-50 and its work station on a per unit time basis. If, for example, we assume that CPU-50's in a particular system send data at the rate of one 250 character message every 3 minutes on the average (where a character is defined as any combination of 8 bits), we can compute the average data rate per second for any population of users. The data flow per channel is 11.11 bits per second ( $250 \times 8 / 3 / 60$ ). If the channel rate is assumed to be 1200 bits per second, then in theory the CPU-50 could support as many as 108 users at a time providing that perfect scheduling of the channel was possible.

Without getting into detailed mathematics, it can be shown that a CPU-50 network using the above parameters can service 37 users on a single channel with delays on the order of 2.5 seconds. By way of comparison, a polling system using a 48 bit polling message would take an average of 4 seconds before polling any one station with a maximum of 9 seconds delay possible under the same conditions.

#### INTRODUCTION

The CPU-50 has been designed to make available a Full Duplex RS-232 data communication path using a radio system as the communication medium. As such it provides a serial link to any RS-232 compatible device such as a computer, computer peripheral, data acquisition unit or other digital devices.

The CPU-50 communicates to another CPU-50, via radio, in a half duplex fashion using packet switching technology. It is a microprocessor controlled device which allows networking of a large number of users on a single radio channel.

Data is exchanged between units using a High Level Data Link Format and packet data transmission techniques to ensure Error Free data transmission.

The CPU-50 allows RS-232 communication on any voice bandwidth, full or half duplex VHF/UHF FM or HF SSB radio transceiver. It is particularly suited and provides a very high data speed (600 baud) on HF as well as 1200 on VHF/UHF. Interfacing is made via a 9 pin DB connector provided at the rear of the unit. Programmable delays and other features in the CPU-50 can be set and permanently stored in battery backed-up RAM, allowing the unit to be uniquely configured to the users radio transceiver. The device uses standard frequency shift keying (FSK) techniques (CCITT V.23) in the audio range to modulate the radio's carrier.

#### Packet Radio Data Transmission

The CPU-50 employs state of the art packet switching techniques. These methods were pioneered on the wired networks often referred to as X.25 protocol, used by Telecom in Australia and other Common Carriers overseas, for both domestic and international data communications. The goal in both cases is improved data integrity along with dramatic gains in spectrum efficiency.

All packet switched systems, whether landline or radio based, share a common principle of operation. Data is assembled into blocks before transmission. Each block is a form of "electronic envelope" which in addition to the data, carries addressing and validation information (the overhead). This envelope is referred to as a packet.

The maximum packet size can be defined by the user. A decision on the packet size is normally based on the average message size, nominal bit error rate (BER) and throughput considerations. If the amount of data input to the CPU-50 is greater than the maximum size of a single packet, then multiple transmissions are sent.

This process of assembling data into packets at the transmission end and stripping away the envelope at the receiving unit is fully transparent to the user.



The example above is conservative and allows very large margins against network overload which any experienced system designer would insist on.

#### Packet Protocols

The CPU-50 using CSMA, as discussed earlier, does not require a polling station or token. If a unit has traffic to offer to the channel it will "sense" the channel and if free, will transmit its data and wait acknowledgment. If the channel is deemed to be in use, it will wait until all other traffic subsides before it transmits its packet. Under these conditions it is possible, using the CSMA method, that conflicts or collisions may arise causing packets to overlap on the channel.

Therefore some method is needed to prevent two or more stations from continually retransmitting their packets and overlapping or again. The CPU-50 solves this problem by invoking a second random transmit delay. If a transmitted packet fails to generate a corresponding ACK the originating CPU-50 will wait a random length of time before sensing the channel prior to a retry thus overcoming a possible collision.

#### Buffering And Flow Control

There will be times when a CPU-50 will not be able to transmit some or all of its data as it arrives at the RS-232 port due to the channel being busy. If this condition occurs the data is stored in packets in the CPU-50's internal memory until it can be transmitted. This buffering is essential when devices connected to a network operate at speeds which are different from the network itself.

As soon as buffering takes place or is even required, the possibility of buffer overflow and the resultant loss of data must be considered. Since buffering can take place at any point on the network, flow control at all levels must be supported to avoid losing data should a memory buffer overflow. The CPU-50 employs complete hardware and software handshaking between the physical device it is connected to and other units on the RF link.

#### Data Rate

The maximum data rate available on the RS-232C port is 9600 baud, asynchronous, full duplex. The modems communicate between each other at 1200 bits/sec, synchronous, half duplex for a VHF/UHF FM radio system or 600 bits/sec using HF SSB radio.

#### GENERAL SPECIFICATIONS

RS-232 FORMAT: Asynchronous 7 bit ASCII, Even parity,  
1 Stop bit (E,7,1), factory set at 9600  
or user reset as follows:

DSW-1/4 ON = 9600  
DSW-1/3 ON = 4800  
DSW-1/2 ON = 2400  
DSW-1/1 ON = 1200

RADIO LINK SPEED: Factory set at 1200 baud for use on VHF/UHF  
or user set to 600 baud for HF SSB radio as  
as follows:

DSW-1/6 ON = 1200  
DSW-1/6 OFF = 600

CGITT V.23 standard signaling tones.

RADIO PORT (DB-9):

Pin 1, Audio Out to TX Input  
Pin 2, Audio In from RX output  
Pin 3, N/C  
Pin 4, Signal Ground  
Pin 5, Open Collector PTT  
Pin 6, DC Ground  
Pin 7, DC Ground  
Pin 8, Switched 12V DC, 500 mA max  
Pin 9, Reserved

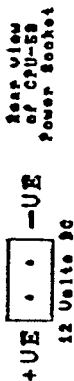
RS-232 PORT (DB-25): The CPU-50's serial port is configured as  
DCE and uses standard modem cabling.

Pin 1 = DC Ground, Pin 2 = TXD, Pin 3 = RXD,  
Pin 4 = N/C, Pin 5 = CTS, Pin 6 = DSR,  
Pin 7 = SIG Ground, Pin 8 = DCD, Pin 20 = DTR.

#### TYPICAL CPU-50/IBM COMPATIBLE WIRING

CPU-50	IBM
1 >-----< 1	
2 >-----< 2	
3 >-----< 3	
20 >-----< 4	
5 >-----< 5	
6 >-----< 6	
7 >-----< 7	
8 >-----< 8	

POWER REQUIREMENTS: 12 Volts +/- 15% @ 30 milliamperes



#### RADIO INTERFACING

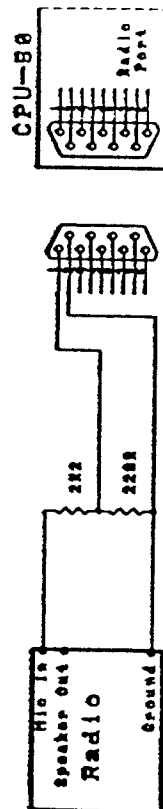
The following are some important points to note when interfacing the CPU-50 to various types of radio equipment. Particularly, fully shielded cabling should always be used and the shield should be properly grounded.

##### 1. Pin 1 (Audio Out)

This pin should be connected to the transmitter 'Audio In' line. 'Audio In' on a transceiver may take the form of a low level connection to the microphone input or it may be a high level Tx 'Audio In' available at an auxiliary socket on the radio.

Use of the latter is preferable as such an input usually accepts a level of around 100 millivolts making TX level adjustment on the modem easier.

If a low level microphone input is to be used we recommend the inclusion of a resistive voltage divider in the circuit as shown below.



#### MIC ATTENUATOR

Such a voltage divider will allow easier level adjustment to the transceiver mic circuitry using the TX LEVEL control on the rear of the CPU-50. In all cases please adhere to the radio manufacturers recommendation for maximum audio input.

##### 2. Pin 2 (AUDIO IN)

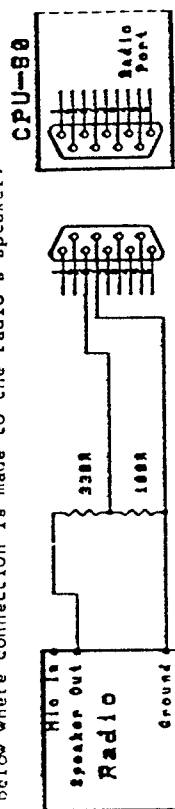
This pin should be connected to the receiver, 'AUDIO OUT' line. Receiver 'AUDIO OUT' on a transceiver may take the form of a high level (in the order of volts) output coming directly from the radio's speaker.

Alternatively it may be a low level (hundreds of millivolts) 'AUDIO OUT' available at an auxiliary socket on the radio.

Use of the latter is preferable as too high an input level to the CPU-50 will cause erroneous operation of the DCD LED on background noise. (Whenever the DCD LED is illuminated the CPU-50 deems the channel to be busy and will not go to air).

The maximum signal level, into pin 2, resulting from receiver background noise must be no more than 50 millivolts.

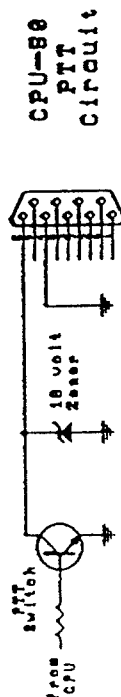
If the receiver output level is higher than that discussed above a resistive voltage divider must be installed. An example is shown below where connection is made to the radio's speaker.



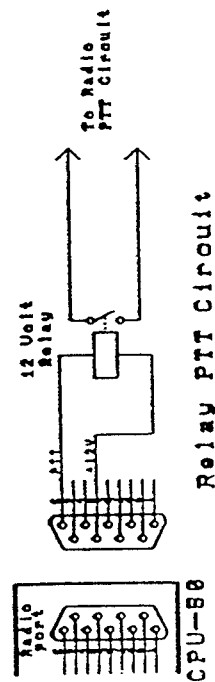
#### SPEAKER ATTENUATOR

##### 3. Pin 5 (PTT)

Should be connected to the radio's push-to-talk line. It represents the Open Circuited collector of an NPN transistor which has its emitter grounded as shown below:-



If an isolated PTT line is required a relay will have to be installed as shown below:-



#### Relay PTT Circuit

**CPU-50 REFERENCE MANUAL** Chapter. 1 Introduction

**RS-232C INTERFACING**

The CPU-50's RS-232 port has been designed as a DCE (Data Communication Equipment) port and as such accepts a standard modem cable (not a Null Modem cable).

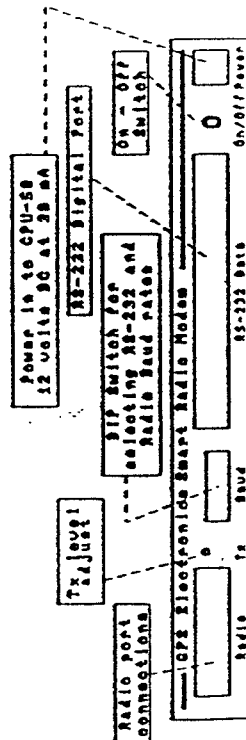
If a cable is to be wired refer to the diagram and pin-outs on page 7 of this manual. As with the radio cable the RS-232 cable should be a fully shielded cable with the shield properly grounded.

**BAUD RATES**

Both RS-232 and Radio Link baud rates are user selectable via a DIP switch (DSW-1) mounted on the rear panel of the CPU-50. Settings for this switch are shown in the table below. Note that DSW-1's switches are 'ON' when DOWN and 'OFF' when UP. Furthermore only one of either DSW-1, DSW-2, DSW-3 or DSW-4 should be ON at any time if the serial port is to operate correctly.

Baud	DSW-1/1	DSW-1/2	DSW-1/3	DSW-1/4	DSW-1/5	DSW-1/6
1200	ON	OFF	OFF	OFF	-	-
2400	OFF	ON	OFF	OFF	-	-
4800	OFF	OFF	ON	OFF	-	-
9600	OFF	OFF	OFF	ON	-	-
19200	-	-	-	-	ON	ON
4800	-	-	-	-	-	OFF

Baud Rate Selection Table



In the following text the term "computer" or "terminal" refers to digital equipment connected to the CPU-50's RS-232 port. Example command prompts issued by the CPU-50 are shown in normal type while the operators responses are shown in bold face and received packets are underlined. Commands and special keywords input to the CPU-50 are in upper and lower case.

**SPECIAL CHARACTERS**

The CPU-50 recognizes a number of special characters in order to perform such functions as Input Editing, Flow Control, and other control functions. Any of the special characters may be changed to suit a particular users application.

A special character may be disabled by setting its value to 0 (zero). Input editing characters may be disabled with no serious effect, however caution should be used when disabling the flow-control or command mode entry characters. Furthermore it is important not to assign two or more special characters the same value.

More detail of these special characters is shown in chapter 3 under the command which sets that particular character.

New code for a character may be entered in either Hex or Decimal notation. The CPU-50 displays the codes in Hex.

Table 2-1. ASCII Control Codes

Dec	Hex	Control Mnemonic	Dec	Hex	Control Mnemonic
0	\$00	CTRL-G	16	\$10	CTRL-P
1	\$01	CTRL-A	17	\$11	CTRL-Q
2	\$02	CTRL-B	18	\$12	CTRL-R
3	\$03	CTRL-C	19	\$13	CTRL-S
4	\$04	CTRL-D	20	\$14	CTRL-T
5	\$05	CTRL-E	21	\$15	CTRL-U
6	\$06	CTRL-F	22	\$16	CTRL-V
7	\$07	CTRL-H	23	\$17	CTRL-W
8	\$08	CTRL-I	24	\$18	CTRL-X
9	\$09	CTRL-J	25	\$19	CTRL-Y
10	\$0A	CTRL-K	26	\$1A	CTRL-Z
11	\$0B	CTRL-L	27	\$1B	CTRL-[
12	\$0C	CTRL-M	28	\$1C	CTRL-\
13	\$0D	CTRL-N	29	\$1D	CTRL-]
14	\$0E	CTRL-O	30	\$1E	CTRL-^
15	\$0F	CTRL-P	31	\$1F	CTRL-_
			127	\$7F	DELETE

## **APPENDIX C**

### **Hardware Description Sheets for Radio and Aerial**

# MAXON DM-0515

## Specifications

### GENERAL SPECIFICATIONS

Power Supply	10.8VDC $\pm$ 5%
Antenna Impedance	50 ohms, unbalanced
Temperature Range	-30 degrees C. to +60 degrees C
Humidity	90%, non-condensing
Frequency Range	148 MHz to 168 MHz
Frequency Stability	$\pm$ 0.0005%
Frequency Control	Quartz crystal, installed
Channel Capacity	1 channel, simplex or half duplex
Required FCC Compliance	Part 15, 21, 90, 95

### RECEIVER PERFORMANCE SPECIFICATIONS

Sensitivity	0.35 $\mu$ V or better (12dB SINAD) (1)
Noise Quieting	20dB or better at 0.5 $\mu$ V (1)
Receiver Recovery After Transmit PTT Released	18 milliseconds or less
Modulation Acceptance Bandwidth	$\pm$ 7.0 kHz
Spurious and Image Rejection	At least -70dB
Intermodulation Rejection	At least -60dB
Selectivity	At least -75dB for frequencies at $\pm$ 25kHz of channel frequency
Audio Output	At least 200mV RMS into 30K ohms @ 2.6kHz deviation with a 1kHz modulation tone
Audio Frequency Response	-4dB maximum @ 4.8kHz, down no more than -10dB at 770kHz (2)
Audio Harmonic Distortion	4% or less with a 10 microvolt input RF level, 1kHz modulating tone at $\pm$ 2.6kHz deviation. (1)
Receiver Current	20mA maximum

### TRANSMITTER PERFORMANCE SPECIFICATIONS

Carrier Power Output	2 watts, $\pm$ 10% depending on voltage source
Audio Harmonic Distortion	No more than 5% for a 1kHz modulating tone at $\pm$ 3.0kHz deviation
Maximum Deviation Capability	At least $\pm$ 5kHz
Modulation Limiting	Instantaneous peak clipping with low pass audio filter
Audio Input Level	250 to 350mV RMS for 5.0kHz deviation @ 1kHz, adjustable
Deviation vs. Temperature	$\pm$ 0.2kHz over operating temperature range
FM Hum and Noise	At least -50dB down
Output Protection	Shall withstand for 5 minutes all VSWR around Smith chart of 20:1 without failure or damage
Input Current	Not more than 600mA with 2 watts average power output at 10.8V
Spurious and Harmonic Emissions	Less than -60dB
Attack Time	Time from PTT to full power, frequency within tolerance, and full modulation capability shall be less than 50 milliseconds
PTT Input	Floating the PTT line enables the receive mode, grounding the PTT line enables the transmit mode. Maximum current sourced from the PTT line during transmit mode with the line tied to ground shall be 30mA

(1): These measurements shall be made using a CCITT weighed filter.

(2): These measurements shall be made without filtering

# MAXON DM-0550

## Pinout Information

Data Radio pin out information for 9 pin D-shell

J2 D-shell	DM	DR	DT
1	Data in	---	Data in
2	Data out	Data out	---
3	PTT	Power Down	PTT
4	Ground	Ground	Ground
5	B+(10.8V)	B+	B+
6	CDS	CDS	---
7	---	---	---
8	---	---	---
9	---	---	---

The pins on the 9 pin D-shell are labeled. Pin 1 as viewed front the front or outside is located at the top left, pin 5 is located at the top right. Pin 6 is located at the bottom left and pin 9 is located at the bottom right.

# MAXON DM-0515

## Crystal Specifications

### TRANSMITTER

Holder .....	HC-18/u wire lead
Mode of Oscillation .....	Fundamental
Load Capacity .....	32 pF parallel
Series Resistance .....	Less than 20 ohms
Drive Level .....	Less than 2 mW
Holder Capacity .....	7 pF Max.
Motional Capacity .....	0.0025pF $\pm$ 10%
Temperature Range (Operating) .....	30°C to 60°C
Frequency Tolerance at 25°C .....	$\pm$ 5 ppm
Frequency Tolerance vs. Temperature ...	$\pm$ 5 ppm, - 10°C to 60°C ( $\pm$ 10ppm, - 30°C to 60°C)
Frequency Calculation .....	Operating frequency divided by 9

### RECEIVER

Holder .....	HC-18/u wire lead
Mode of Oscillation .....	Fundamental
Load Capacity .....	32pF parallel
Series Resistance .....	Less than 20 ohms
Drive Level .....	Less than 2 mW
Holder Capacity .....	7pF Max.
Temperature Range (Operating) .....	- 30°C to 60°C
Frequency Tolerance at 25°C .....	$\pm$ 10 ppm
Frequency Calculation .....	(Fo—10.7)/9
Frequency Tolerance VS. Temperature .....	$\pm$ 10 ppm - 10°C to 50°C

# MAXON DM-0515

## Alignment Instructions

### RECEIVER

#### Crystal Installation

Soldering of the crystals must be accomplished quickly to avoid damage to the crystal itself.

#### Oscillator Tuning

Connect a VOM (0-3VDC range) at TP-1; tune T9 for maximum reading.

#### Front end Tuning

Connect a SINAD indicating meter across the audio output connections using a CCITT weighted filter. Tune the signal generator to the proper frequency and increase its output until the signal (3 kHz deviation, 1 kHz audio tone) can be heard. T1, T2, T3, T4, and T8, T9, T10 for best SINAD. Adjust the channel trimmer capacitor for best SINAD at the indicated channel frequency, using the minimum possible output from the signal generator. Go back and touch up the tuning of T1 through T10, above, as well as T5 and T8. The final SINAD reading for any selected channel within the 5 MHz permissible spread should be 0.35 microV or less for 12dB. T7 is factory-tuned and does not normally require adjustment.

### RECEIVER PERFORMANCE TESTS

#### SINAD Sensitivity

Adjust the signal generator output to the lowest level which will provide a good sinusoidal pattern on the oscilloscope. At 12 dB SINAD the signal generator output should be less than 0.35 microV.

#### Noise Quieting Sensitivity

With the signal generator connected to the radio with no modulation the 20dB quieting point should be approximately 0.5 microV.

#### Carrier Detect Switch Sensitivity

With the signal generator set for 1 kHz modulation, 3 kHz deviation and the RF attenuator at minimum output setting, adjust the control to its threshold, i.e. to where Q4 collector just goes high. The collector of Q4 should go low as the output of the signal is increased to 0.25 microV. Set the control to its maximum clockwise position. Increase the RF attenuator setting until Q4 collector goes low. The point of opening should be 10 to 20dB greater than 0.25 microV.

#### Audio Output

With the signal generator set at 1000 microV output, audio output should be approximately 50 to 150 mV.

#### Standby Current

Squelch the receiver (no signal input) and connect a VOM (0-3mA scale) in series with one of the power supply leads. The meter reading should be less than 20mA at a supply voltage of 11 volts.

### TRANSMITTER

#### Crystal Installation

Soldering of the crystals must be accomplished quickly to avoid damage to the crystal itself.

#### Power Supply Voltage

Set the power supply voltage to the proper level, measured at the radio, not at the power supply. If measured at the power supply, voltage drop in the connecting leads will result in erroneous readings.

#### Multiplier Tuning

Connect an RF wattmeter (0-5W scale) to the antenna jack and a 0-3VDC voltmeter to TP-4 and press the PTT switch. Tune T11, T12, T13 for maximum and T14 for a dip. Move the meter to TP-5 and touch up the coils mentioned above for maximum reading.



# MAXON DM-0515

## Alignment Instructions (Continued)

### Amplifier Tuning

Press the PTT switch and observe some reading on the RF wattmeter. Tune TC9, TC10, and TC11 for maximum RF output as indicated on the wattmeter, while observing the spectrum analyzer to ensure that all spurious emissions are down at least 60 dB relative to the carrier level.

### Channel Setting

Adjust the trimmer capacitor for transmitter crystal to the exact channel frequency, as measured on a communications monitor or suitable frequency counter.

### Deviation Adjustment

Using an external audio generator connected to the radio's pin 1 of J2 set the deviation control (RV1) to indicated plus/minus 5 kHz on the communications monitor, observing the wave-form for proper positive and negative peak deviation. Note that when the modulation limiter is over-driven, slight "carrier shift" will result. This will not occur at normal audio levels. Also note that when crystals for more than one channel are installed, there will be a slight difference in maximum deviation for a given setting of RV1. This is caused by slight variation in individual crystal parameters and can be minimized by using crystals from the same manufacturer. Always adjust RV1 for 5 kHz deviation on the channel which shows maximum deviation.

## TRANSMITTER PERFORMANCE TESTS

### Power Output

Power output should be in excess of the advertized specification with a power supply input voltage of the required level (11 Volts), measured at the power supply. Reducing the supply voltage by 15% should produce a power output of approximately 50% the advertized specification.

### Audio Response

Connect an audio generator set up for 1 kHz to the pin 1 of J-2. Adjust the generator output to 1 kHz deviation on the deviation meter. Retune the audio generator to 500 Hz. The deviation should now be approximately 500 Hz as observed on the monitor. Retune the audio generator to 2 kHz. The deviation should now be approximately 1 kHz.

### Limiting Test

Adjust the audio generator output to 1 kHz deviation at 1 kHz audio frequency tone output and observe the waveform on an oscilloscope connected to the communications monitor. Set the attenuator on the audio generator to show slight clipping on the oscilloscope. Increase the generator by 20 dB (twice voltage) and sweep the band from 300 Hz to 3 kHz. At any frequency within that band the deviation should not exceed plus/minus 5 kHz.

### Splatter Filter Test

With the test equipment set up as for the LIMITING TEST, note the reading on the AC VTVM connected across the audio output of the deviation meter at 3 KHz deviation. Tune the audio generator to 6 kHz. The AC VTVM reading should decrease more than 18 dB.

### Spectrum Test

With the input attenuator of the spectrum analyzer protected by 30 to 40 dB of attenuation, all spurious and harmonics should be down more than 60 dB.

### Antenna Test

Reassemble the radio into its case and install a fully-charged battery pack. Connect a properly trimmed (to frequency) flexible antenna. A ground on J-2 pin 3 and check the frequency, deviation and spectral purity. All should be the same as tested with the 50 ohm dummy load.

# Installation

## CD28-41-70 Series

### Mopole Antennas

148-174MHz

The CD28-41-70 Series Antenna is an range of end fed dipole(Mopole) which is ground plane independent. The antenna has a high impedance matching circuit which is enclosed in a high impact ABS housing. The CD28-41-70 uses a tapered 17-7PH stainless steel radiating section. In the feed design the terminated RG58 forms part of the high impedance matching circuit and no D.C. continuity exists between the centre conductor of the cable and the radiating element and a short exists from the cable shield to the radiating element.

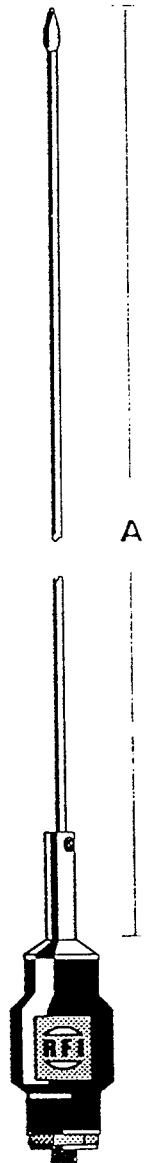
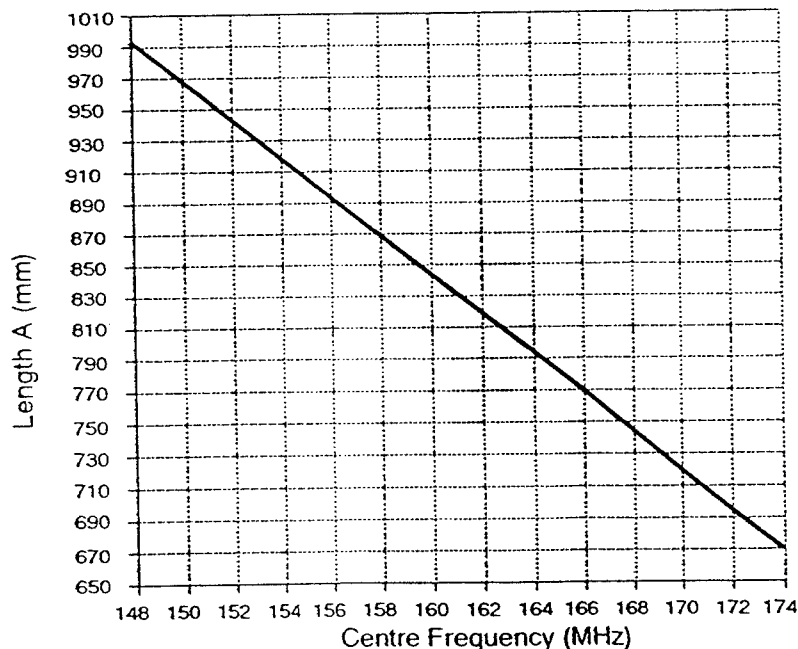
### To Terminate The Antenna:

1. Remove approximately 50mm of the outer PVC jacket of the RG58 cable.
2. Trim the exposed cable braid shield so that approximately 10-15mm remains showing.
3. Fold the remaining braid shield back over the outer PVC jacket of the cable as shown.
4. Trim the exposed inner conductor, complete with insulation to the EXACT length shown below.(67mm)
5. Screw the prepared cable into the coil housing until the cable 'bottoms'. The cable is now terminated. No soldering of the conductors is necessary. Please note the D.C. continuity checks above.
6. Trim whip top to frequency using an inline VSWR meter. (Chart below serves as an accurate guide if cable preparation is correct).

### RG58 CABLE

148-174MHz

67mm



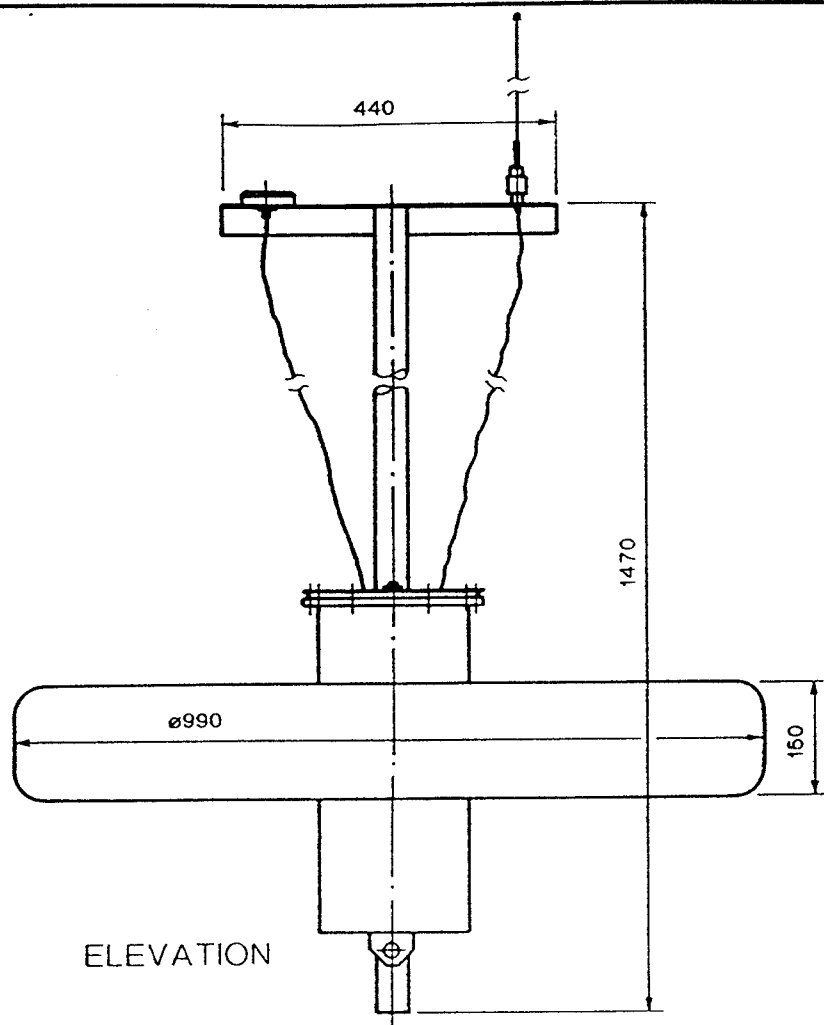
Aust. Patent no. 496830



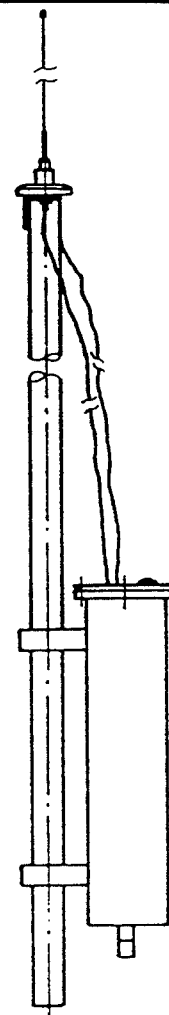
R F Industries Pty. Ltd.

## **APPENDIX D**

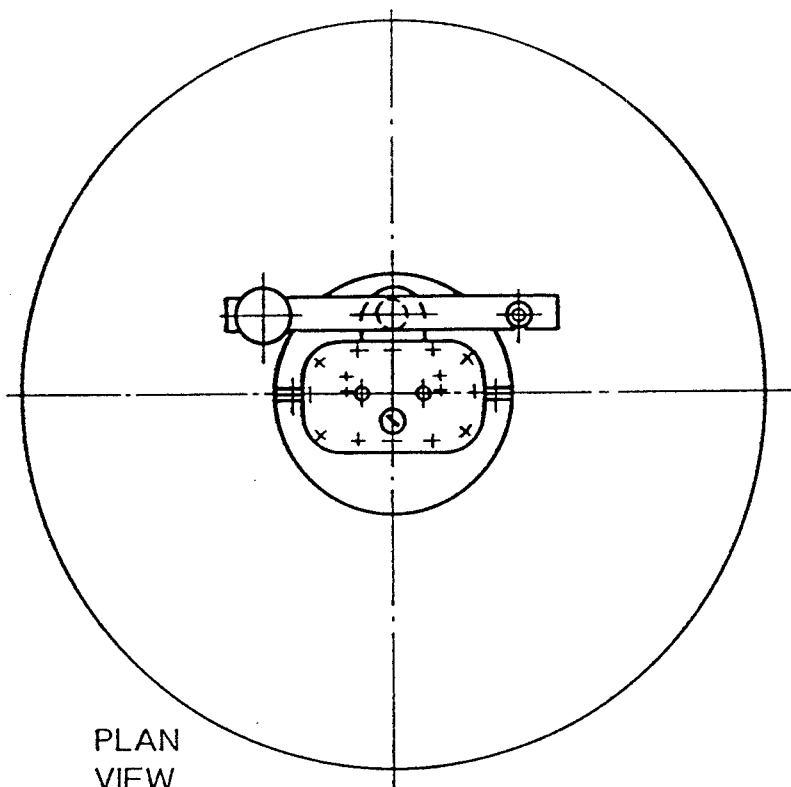
### **Technical Drawings of Drifter Unit and Shore Station Housing**



ELEVATION

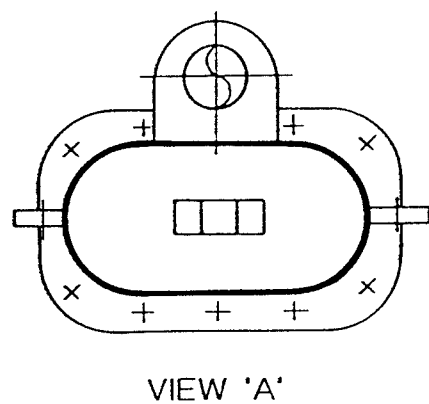
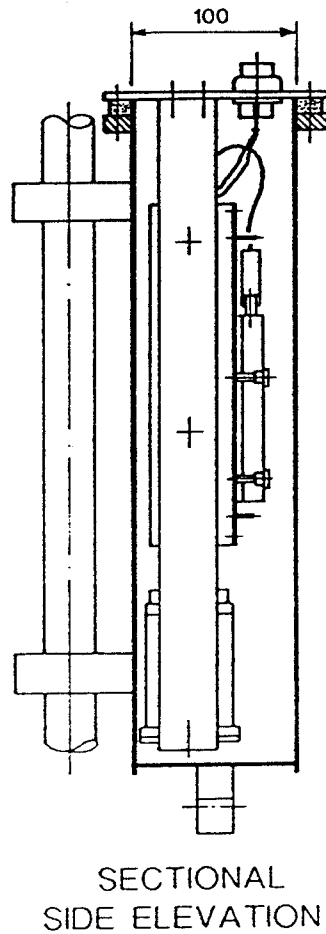
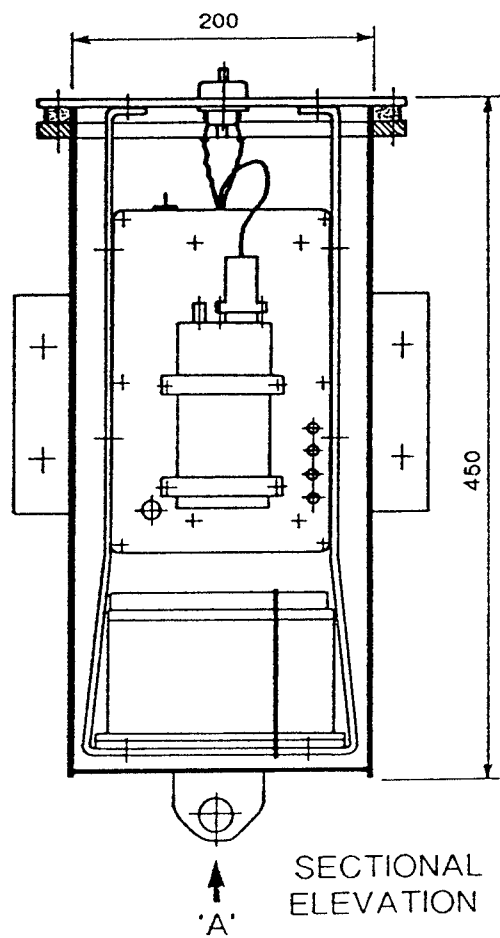


SIDE  
ELEVATION  
(HULL REMOVED)

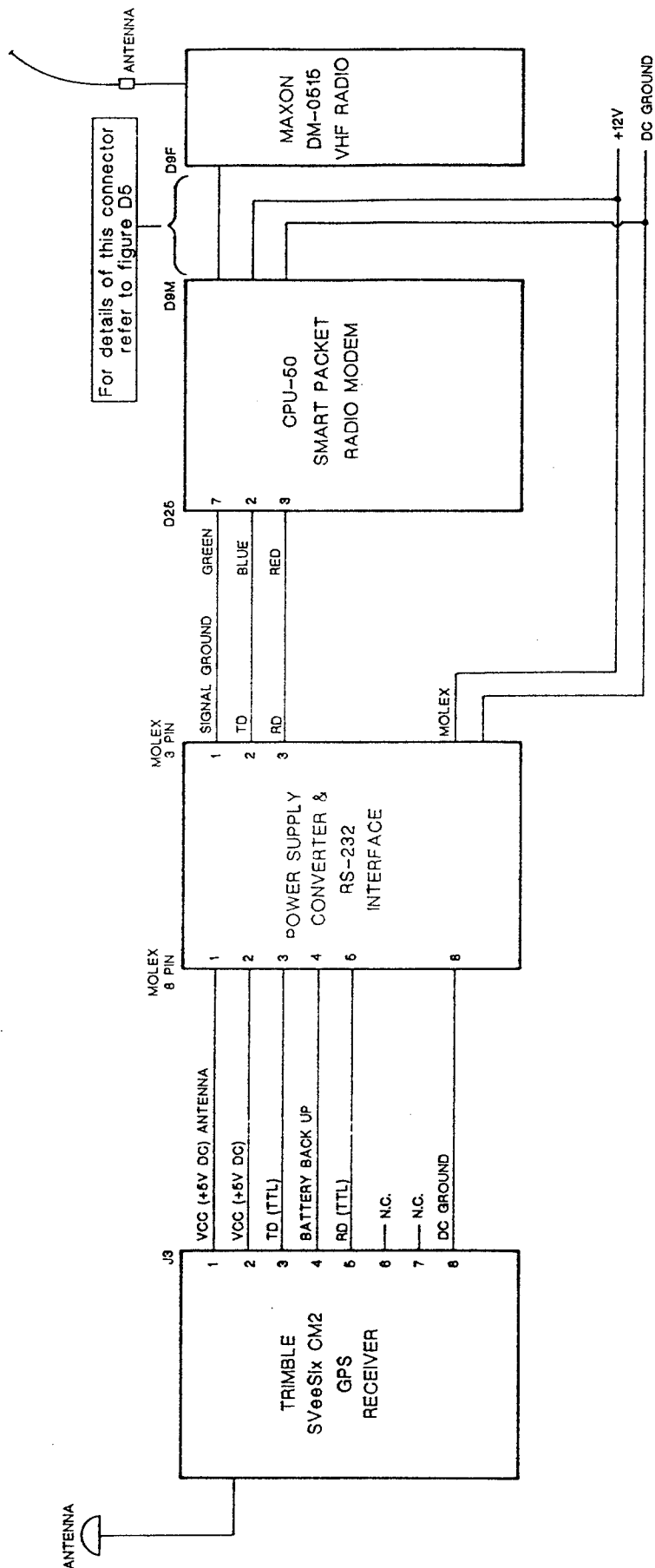


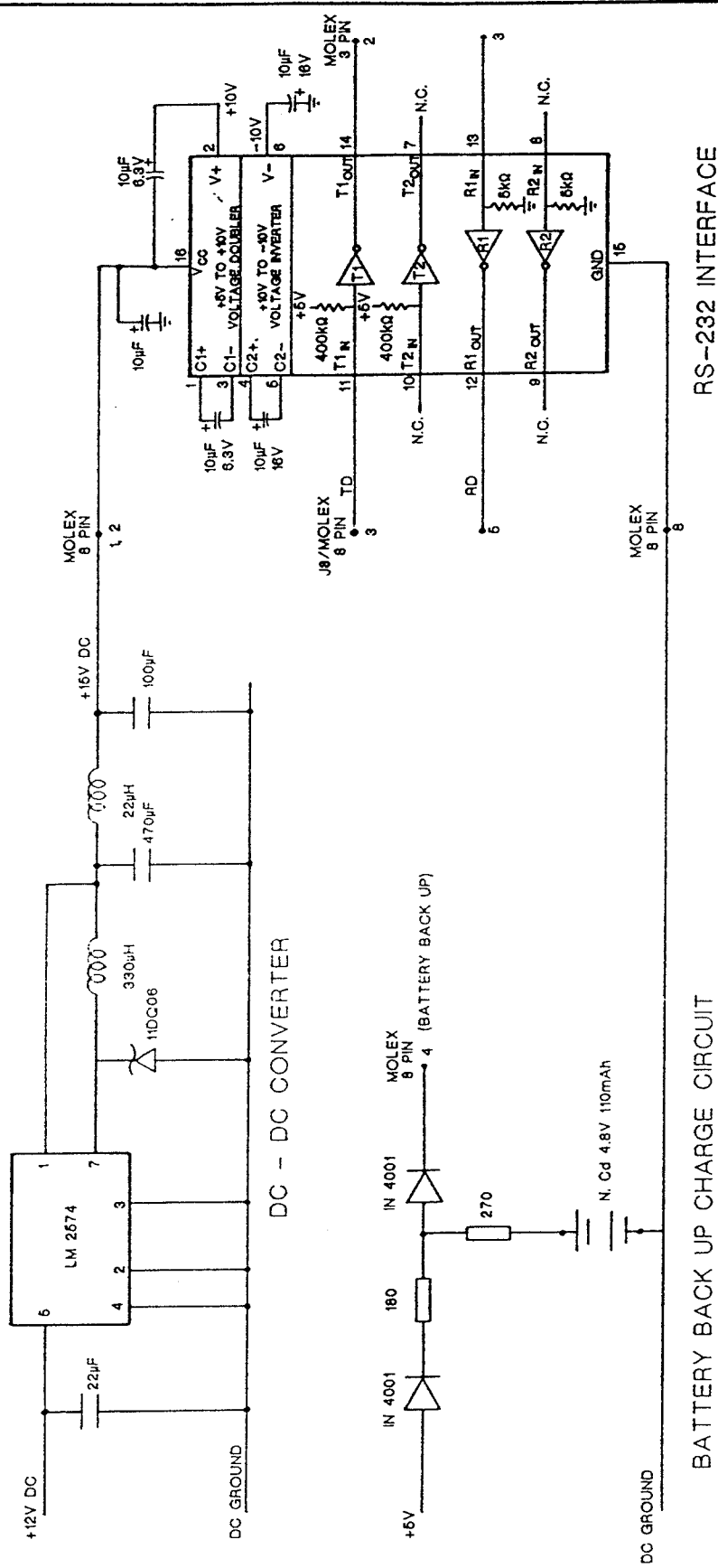
PLAN  
VIEW

SCALE 1:10  
DIMENSIONS IN mm



SCALE 1:5  
DIMENSIONS IN mm





BATTERY BACK UP CHARGE CIRCUIT

RS-232 INTERFACE

